

METHOD AND TESTING DEVICE FOR VERIFYING THE CHARGE INVOICING  
FOR A COMMUNICATIONS CONNECTION ACCORDING TO TIME-UNIT  
INTERVALS

The present invention relates to a testing device and a method for verifying the charge invoicing for a communications connection according to time-unit intervals, where a testing device able to simulate at least one calling, analog terminal  
5 device and at least one called terminal device is connected to at least one network node that generates time pulses.

Analog telecommunications networks are distinguished in that, inter alia, the charge for a communications connection is calculated according to time-unit intervals. Such charge  
10 invoicing is also necessary today in the age of digital communications networks, when analog terminals, such as pay telephones, are used as a calling, terminal device.

In order to be able to determine the price of a communications connection according to time-unit intervals, a switching  
15 network node connected to the calling terminal device generates time pulses. The switching network node may transmit the generated pulses to the calling terminal device for the purpose of calculating payment, when it is, e.g. a pay telephone. Each pulse corresponds to a specific monetary  
20 value. In each instance, the connection price payable per unit time may be set by selecting the interval of consecutive pulses. The conditions for correctly calculating payment according to time-unit intervals are that

a) the difference between the length of the contractually  
25 agreed-upon, time-unit interval and the length of the billed time-unit interval does not exceed a predetermined value, which is, as a rule, less than one second;

b) the first pulse is generated in the network node within a predetermined time span after the start of the communications connection; and

5 c) not more than y time pulses are generated after the end of the communications connection, the last time pulse only being allowed to be generated within a predetermined time span.

Till now, there has been no testing methods and testing systems, by which the calculation of a connection price  
10 according to time-unit intervals may be validated.

Therefore, the present invention is based on the problem of providing a method and a testing device for verifying the charge invoicing for a communications connection according to time-unit intervals.

15 First of all, the present invention solves the problem via the method steps according to Claim 1.

The method employs a testing device, which may simulate at least one calling, analog terminal device and at least one called terminal device and is connected to at least one  
20 network node that generates time pulses. The network node is normally an analog or digital, switching network node. Using the testing method, at least one predetermined, test-communications connection may be set up and torn down again in the network node.

25 First of all, the interval between the start of the test-communications connection and the generation of a first time pulse in the network node is determined, and it is checked if the ascertained interval is within a first predetermined time domain.

During the existing test-communications connection, time-unit intervals of consecutive time pulses are measured and compared to a predetermined time interval. All of the time-unit intervals occurring between the start and the end of the test-communications connection are advantageously measured.

In addition, it is checked if at least one additional time pulse has been received after the end of the test-communications connection. When this is the case, the time interval between the end of the test-communications connection and the at least one time pulse is ascertained. It is checked if the ascertained interval is within a second predetermined time domain.

Advantageous further developments constitute the subject matter of the dependent claims.

The time interval between the start of the test-communications connection and generation of the first time pulse is measured, using the following steps: The occurrence of a first predetermined event (connect; loop connection), which corresponds to the measurable start of the test-communications connection, is detected at a first predetermined measuring point of the testing device. The reception of the first time pulse of the test-communications connection, which time pulse is generated by the network node, is detected at a second predetermined measuring point of the testing device.

A time measurement is started or stopped as a function of the detected occurrence of the first predetermined event (connect; loop connection) and the reception of the first time pulse.

The first measuring point is preferably in the called terminal device, and the second measuring point is preferably in the calling, analog terminal device. The event detected at the first measuring point may be the protocol message "connect" in

the case of a digital, called terminal device, or the event detected at the first measuring point may be the formation of a loop connection in the case of an analog, called terminal device.

5 Since the first and second measuring points are situated away from the network node, the occurrence of the actual event "start of connection", which may be at an interface of the network node, and the recording of the event "start of connection" detected at the first measuring point are  
10 separated in time. In the same manner, the reception of the first time pulse at the second measuring point and the actual generation of the first time pulse in the network node are separated in time. These temporal deviations are referred to as a systematic measuring error between the location of an  
15 actual event and the first or second measuring point that detects this event. The systematic measuring error is a function of the chosen test procedure and must therefore be ascertained for every test scenario.

In order to increase the measuring accuracy of the testing  
20 method, the systematic, temporal measuring error between the location of an actual event, which may be an interface of the network node, and the predetermined measuring point in question, which detects this event, is ascertained.

To this end, e.g. the systematic measuring error between the  
25 location of the actual occurrence of the start of the test-communications connection and the first measuring point of the testing device, and the systematic measuring error between the location of the actual generation of the first time pulse and the second measuring point of the testing device, are  
30 ascertained. The time interval between the detected occurrence of the first predetermined event and the reception of the first time pulse is measured and corrected by the amounts of

the systematic measuring errors. It is then checked if the corrected interval is within the first predetermined time domain.

5 The time intervals of consecutive time pulses are advantageously measured, using the following steps:

10 The first time pulse received by the calling, analog terminal device starts a first time measurement; in each instance, each subsequent time pulse arriving at the calling, analog terminal device stops the time measurement, which has been started by the immediately preceding time pulse, and starts a further time measurement. An  $i^{\text{th}}$  time measurement is started by the last time pulse of the test-communications connection. If the  $i^{\text{th}}$  time measurement is not stopped by a further time pulse, then this signals the end of the connection-price calculation.

15 In this case, the value of the  $i^{\text{th}}$  time measurement is discarded. The  $i^{\text{th}}$  time measurement may then be stopped, for example, after a predetermined time elapses.

Each initiated time measurement for ascertaining the time interval of two consecutive time pulses may be assigned a serial number.

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At this point, it should be mentioned that the time measurements may be carried out by software or hardware. In the case of software implementation, the duration of each occurring interval between two time pulses is measured and stored in a storage device. The stored values are then compared to the predetermined time interval. In the case of hardware implementation, e.g. two timers are sufficient, which are each reset to zero after measuring the duration of a time interval, the measured value of the timer in question being written beforehand to a storage device.

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Testing methods, which are used in the validation of the calculation of connection prices, must be capable of testing whether time pulses generated after the end of the connection may still occur.

- 5 To this end, the time interval between the end of the test-communications connection and a first time pulse received after the end of the test-communications connection is ascertained by the following steps:

10 A time measurement is initiated, when a second predetermined event (disconnect; loop interruption), which corresponds to the measurable end of the test-communications connection, occurs at the first or second predetermined measuring point of the testing device. The number of the currently active time measurement of the temporal spacing of two consecutive time  
15 pulses is simultaneously recorded. The time measurement initiated by the second predetermined event is stopped, when the first time pulse is received at the second predetermined measuring point of the testing device after the end of the test-communications connection. The value of this time  
20 measurement is compared to the second predetermined time domain, when no further time pulses are received within a predetermined time span.

It should be said that when no time pulses are received after the end of the test-communications connection, the time  
25 measurement initiated by the second predetermined event is stopped, for example, after the expiration of a predetermined period of time. In this case, the value of the time measurement is set to "0".

In general, the values of time measurements may only be  
30 evaluated, when the measurement of the time intervals of consecutive time pulses is ended. Thus, it is possible for not only one time pulse, but rather several time pulses to occur

after the end of the test-communications connection. The test as to whether these time pulses were allowed to occur is carried out as follows:

5 The value of the time measurement for the interval between the end of the test-communications connection and the first time pulse received after the end of the test-communications connection, and the values of all time measurements for time intervals of consecutive pulses, whose numbers are greater than the number of the time measurement of the interval of two  
10 consecutive time pulses that were active at the end of the connection, are added and compared to the second predetermined time domain.

In addition, the number of time measurements, whose numbers are greater than the number of the time measurement of the  
15 interval of two consecutive time pulses, which were active at the end of the connection, may additionally be determined. From this number, it may be determined if the number of time pulses, which have occurred after the end of the test-communications connection, is less than, greater than, or  
20 equal to maximum permissible number y of time pulses.

The accuracy of the test method may be improved by more accurately calculating the interval of the actual occurrence of the end of the test-communications connection and the actual generation of time pulses.

25 Therefore, the systematic measuring error between the location of the actual occurrence of the end of the test-communications connection and the first and/or second measuring point of the testing device, as well as the systematic measuring error between the location of the actual generation of time pulses  
30 and the second measuring point of the testing device, are measured. The time interval between the occurrence of the second predetermined event (disconnect; loop interruption) and

the reception of a subsequently occurring time pulse is measured and corrected by the amount of the systematic measuring error.

5 In this manner, it is taken into account that the measuring points are situated away from the network node and that, therefore, the occurrence of the actual event "end of connection", which may occur at an interface of the network node, and the detection of the event "end of connection", are separated in time. In the same manner, the reception of the  
10 last time pulse and the actual generation of the last time pulse in the network node occur at different times.

In order to be able to keep the systematic measuring errors small, the first measuring point is determined by the called terminal device, and the second measuring point is determined  
15 by the calling, analog terminal device; the test-communications connection also being able to be ended at the two terminal devices.

At this point, it should again be emphasized that a useful objective of the present invention is to calculate as  
20 accurately as possible the actual, immeasurable time of the start and end of a test-communications connection, as well as the actual, immeasurable time of the generation of a time pulse.

The above-mentioned problem is additionally solved by the  
25 features of Claim 10.

Claim 10 provides a testing device for connection to at least one network node to be tested, which may emit time pulses. The testing device has the following features:  
a call simulator for simulating at least one calling, analog  
30 terminal device and for simulating at least one further terminal device, which may be operated as a called terminal



device;

a first detector device for detecting time pulses;

a second detector device for detecting a first predetermined event (connect, loop closure), which corresponds to the

5 measurable start of a test-communications connection;

the first and/or second detector device being designed to detect a second predetermined event (disconnect; loop interruption), which corresponds to the measurable end of a test-communications connection.

10 Additionally provided are a first time-measuring instrument for measuring, in each instance, time intervals of two consecutive time pulses;

a second time-measuring instrument for measuring the interval between the occurrence of the first predetermined event and

15 the reception of the first time pulse of a set up test-communications connection;

a third time-measuring instrument for measuring the interval between the occurrence of the second predetermined event and the reception of at least one time pulse after the measured

20 end of the test-communications connection;

and an evaluation device, which can compare the measured time spans of the specific time-measuring devices to corresponding, predetermined time domains. In addition, evaluation device may

25 check if the number of time pulses occurring after the end of the test-communications connection is less than, greater than, or equal to predetermined, maximum number y of time pulses.

In order to be able to improve the measuring accuracy of the testing device, a storage device is additionally provided, in which the systematic error between the location of the actual

30 start of the test-communications connection and the second detector device, the systematic measuring error between the location of the actual end of a test-communications connection and the first or second detector device, and the systematic

measuring error between the location of the actual generation of time pulses and the first detector device of the testing device are stored. A correction device connected to the storage device is used to correct the values measured by the first, second, and third time-measuring devices by the amount of the respective systematic measuring errors.

In order to be able to test if time pulses received after the end of the test-communications connection may occur, a device, preferably the first time-measuring device, is designed to serially number consecutive time intervals. Furthermore, in response to the numbers assigned to the time intervals, the third time-measuring device can detect if a time interval has been measured in the first time-measuring device after the detection of the second predetermined event (disconnect, loop interruption). For example, the third time-measuring device or evaluation device may add the value for the interval between the end of the test-communications connection and the first time pulse received after the end of the test-communications connection and the values of all of the measured time intervals, whose numbers are, in each instance, greater than the number of the time interval, which has been instantaneously measured in response to the occurrence of the second predetermined event (disconnect; loop interruption) at the first or second detector device of the testing device.

In order to keep the systematic measuring errors as small as possible, the first detector device may be assigned to the calling, analog terminal device, the second detector device being able to be assigned to the called terminal device.

The present invention is explained in detail below on the basis of an exemplary embodiment, in conjunction with the attached drawing.

The figure shows an exemplary testing device 10, which includes at least one call simulator 100 that can simulate an analog terminal device 20 as a calling terminal device and a terminal device 30 as a called terminal device. Analog  
5 terminal device 20 is connected, via an interface 42, to a switching network node 40 to be tested. Terminal device 30, which is a digital terminal device in the present example, is connected to switching network node 40 via an interface 44. Also conceivable is a test connection, in which terminal  
10 device 30 is connected to another switching network node.

Analog terminal device 20 has a detector device 22, which may detect, inter alia, time pulses generated by network node 40. In addition, analog terminal device 20 has a time-measuring device 24, which is implemented in the form of hardware or  
15 software and is capable of measuring, in each instance, time intervals between two consecutive time pulses. Schematically represented time-measuring device 24 has, for example,  $N+1$  timers  $24_1$  through  $24_{N+1}$ , by which  $N+1$  time intervals may be measured. The measured time intervals are each assigned a  
20 serial number between 1 and  $N+1$ , whose significance is described further down. The time intervals may be stored together with the corresponding number in a memory 26. Analog terminal device 20 may additionally have a generator 29, which generates a loop interruption when a test connection is ended  
25 at analog terminal device 20.

Terminal device 30 has a generator 32 for generating an event, which signals the start and possibly the end of a test connection. In the case of a digital terminal device, the protocol message "connect" or "disconnect" is generated as an  
30 event, while in the case of an analog terminal device 30, a loop closure or a loop interruption is generated as an event. These events are detected by a detector 34.

Testing device 10 has a further time-measuring device 50, which is connected, for example, to detectors 22 and 34. The interval between the start of a test connection detected at detector 34 and the first time pulse detected at detector 22  
5 may be measured by time-measuring device 50.

In addition, a time-measuring device 55 is provided, which can measure the interval between the end of a test connection detected at detector 22 or 34 and a time pulse, which is detected at detector 22 and is generated in network node 40  
10 after the end of the test connection. To this end, time-measuring device 55 is connected to detectors 22 and 34. Furthermore, time-measuring device 55 is connected to time-measuring device 24, in order to obtain the numbers of the measured time intervals and, in some instances, the temporal  
15 length of particular time intervals.

Stored in a storage device 80 are temporal correction values, which correspond to the systematic measuring errors between interfaces 42 and 44 of network node 40 as locations of the actual events, i.e. generation of time pulses and detection of  
20 the start and end of a connection, and to detectors 22 and 34 as a location of the measured events.

A correction device 90 is connected to storage device 26, time-measuring devices 50 and 55, and storage device 80. Since the time intervals measured in time-measuring device 24 and  
25 stored in storage device 26 do not have to be corrected, these are simply looped, together with the corresponding number, to an evaluation device 70, via only correction device 70. On the other hand, the values coming from time-measuring devices 50 and 55 are corrected in correction device 90 by the amount of  
30 the systematic measuring errors stored in storage device 80, and then transmitted to evaluation device 70.

Evaluation device 70 is also connected to a storage device 60, in which reference values are stored. The reference values correspond to, in particular, the predetermined time-interval length which may be a function of the selected test procedure, a predetermined interval which may be between the actual start of the connection and the generation of the first time pulse, an additional predetermined interval which defines the maximum time interval that may lie between the actual end of the test connection and the last, subsequently generated time pulse, as well as a maximum number y of time pulses which may be generated after the end of the test-communications connection. In addition, another reference value may be stored for a minimum number x of time pulses, which may be generated after the end of the test-communications connection.

The method of functioning of testing device 10 illustrated in the figure is explained in detail in the following.

At this point, it is assumed that a test connection should be established from analog terminal device 20 to terminal device 30 via switching node 40. Analog terminal device 20 transmits, inter alia, the call number of terminal device 30 to the network node, which then transmits a ringing signal to terminal device 30. From the received call number, network node 40 ascertains the contractual length of the time intervals, which are relevant to the calculation of the connection costs. The length of this time interval is stored in memory 60 as a reference value for the selected test connection.

In response to the ringing signal, e.g. the lifting of the telephone receiver is simulated in terminal device 30. The protocol message "connect" generated in generator 32 is then transmitted to interface 44 of network node 40. In the present example, the protocol message "connect" is initially detected

in detector device 34, which subsequently initiates a time measurement with the aid of time-measuring device 50.

In response to the reception of the protocol message "connect" at interface 44, network node 40 transmits a first time pulse, the so-called starting pulse, to analog, calling terminal device 20. Detector 22 detects the received starting pulse and stops timer 50. Therefore, the measurement of the time interval between the generation of the protocol message "connect" and the reception of the starting pulse is also ended at analog terminal device 20.

This starting pulse (first counting pulse) may deviate by, at most, a first predetermined time span from the actual start of the connection.

The time interval measured by clock 50 is subject to a systematic measuring error. The reason for the systematic measuring error is that the measuring points, locations in analog terminal device 20 and in terminal device 30, are not the locations of the actual events, for, in the present example, the locations, at which the starting pulse is actually emitted and the start of the connection (reception of protocol message "connect") actually occurs, are interfaces 42 and 44 of network node 40. The time deviation, which is caused by the separation of the locations at which the events actually occur and the measuring points at which these events are measured, represents the systematic measuring error, which is ascertained prior to the start of the test and stored in memory 80. In the present example, the systematic measuring error approximately corresponds to the signal propagation time of the protocol message "connect" from terminal device 30 to network node 40 and the signal propagation time of the starting pulse from network node 40 to analog terminal device 20. Therefore, time-measuring device 50 supplies the measured

time interval to correction device 90, in which the time interval is corrected by the amount of the systematic measuring error.

5 In evaluation device 70, the corrected interval is compared to the corresponding reference value from memory 60, in order to be able to determine if the time between the two events is, at a maximum, the first predetermined time span.

10 During the existing connection, network node 40 continually sends time pulses to analog terminal device 20, which are detected by detector 22.

In each instance, the spacing of two consecutive time pulses may not exceed the allowable tolerance. Therefore, the maintenance of this tolerance must be monitored up to the end of the test connection and, in some cases, permanently.

15 Initially, the starting pulse starts first timer  $24_1$  of time-measuring device 24, the next time pulse stops first timer  $24_1$  and starts the second timer, etc., until the last time pulse received during the existing test connection stops timer  $24_{N-1}$  and starts timer  $24_N$ . At the same time, each measured time  
20 interval is assigned a serial number. The numbers and the corresponding time intervals are stored in storage device 26. A time pulse following the measured end of the connection stops timer  $24_N$  and starts timer  $24_{N+1}$ . Timer  $24_{N+1}$  may be  
25 stopped when, after the end of the test connection, no further time pulse is received within a predetermined time span, which has a length of, e.g. two time intervals. The content of timer  $24_{N+1}$  is then discarded.

30 The time intervals stored in memory 26 are transmitted uncorrected, together with the corresponding numbers, to evaluation device 70 via correction device 90. Therefore, it is not necessary to correct the length of the time intervals.

The reason for this is that, in the case of this testing device, the systematic measuring error results, on one hand, from the propagation time of the time pulses from network node 40 to analog terminal device 20, and on the other hand, from the processing speed of testing device 10. The result of the two is that, in testing device 10, the event "network node 40 sends time pulse" is only detected with a time delay. This delay may be regarded as constant. Therefore, the measurement of the interval length yields a systematic measuring error of  $\pm 0$  ms.

Evaluation device 70 compares the measured time intervals to the reference time interval stored in memory 60 and checks if the permissible tolerance is maintained.

Now it is assumed that the test connection is ended at terminal device 30. In this case, the event "telephone receiver hung up" is simulated in terminal device 30. Generator 32 then transmits the protocol message "disconnect" to interface 44 of network node 40. In the present example, the protocol message "disconnect" is detected by detector 34, which consequently starts time-measuring device 55. At the same time, testing device 10 determines number N of currently active timers  $24_N$ .

Two cases are subsequently considered. In the first case, only one time pulse is received in analog terminal device 20, after the protocol message "disconnect" has been generated by generator 32. In the second case, two more time pulses are received in analog terminal device 20, after the protocol message "disconnect" has been generated by generator 32. If more than two time pulses are received in terminal device 20, the method of functioning of the testing device corresponds to the second case.

We will initially discuss the first case.



It is assumed that one more time pulse is detected by detector 22, after the protocol message "disconnect" has been generated by generator 32. In response to the reception of this time pulse, time-measuring device 55 and timer  $24_N$  are stopped, while timer  $24_{N+1}$  is started.

The value of time-measuring device 55 corresponds to the interval between the generation of the protocol message "disconnect" and the reception of the one time pulse.

However, this measured interval must still be corrected in correction device 90 by the amount of the systematic measuring error stored in memory 80.

For, as mentioned above, the measuring points in terminal device 20 and in terminal device 30 are not the locations of the actual events "end of connection" and "generation of a time pulse". This is because, in the present example, the locations at which the time pulse is actually emitted and the end of the connection (reception of protocol message "disconnect") actually occurs are interfaces 42 and 44, respectively, of network node 40. The time deviation, which is caused by the separation of the locations at which the events actually occur and the measuring points at which these events are measured, represents a systematic measuring error, which is stored in memory 80. In the present example, the systematic measuring error approximately corresponds to the signal propagation time of the protocol message "disconnect" from terminal device 30 to network node 40 and the signal propagation time of a time pulse from network node 40 to analog terminal device 20.

The corrected value is transmitted, together with number  $N$ , to evaluation device 70, where it is compared to the second predetermined time value, in order to be able to determine if the corrected value is less than or equal to the second

predetermined time value. In addition, evaluation device 70 can also check if the number of time pulses occurring after the end of the test-communications connection is in the interval between x and y.

- 5 The second case will now be discussed, in which exactly two time pulses are received in analog terminal device 20, after the protocol message "disconnect" has been generated by generator 32.

10 It is assumed that a first time pulse is detected by detector 22, after the protocol message "disconnect" has been generated by generator 32. In response to the reception of this first time pulse, time-measuring device 55 and timer  $24_N$  are stopped, while timer  $24_{N+1}$  is started. In addition, the time interval measured by timer  $24_N$  is assigned serial number N.

- 15 A second time pulse is detected by detector 22. In response to the second time pulse, timer  $24_{N+1}$  is stopped, and the time interval measured by timer  $24_{N+1}$  is assigned serial number N+1.

20 Using the serial number of timer  $24_{N+1}$ , time-measuring device 55 may detect that after the protocol message "disconnect" has been generated by generator 32, a complete time interval N+1 has been measured, and the time-measuring device adds this value to the value of time-measuring device 55, which corresponds to the time interval between the generation of the protocol message "disconnect" and the reception of the first  
25 time pulse.

The time interval ascertained in time-measuring device 55 is still corrected in correction device 90 by the amount of the systematic measuring error stored in storage device 80, and transmitted, together with number N, to evaluation device 70.

- 30 Evaluation device 70 checks if the calculated value is less than or equal to the second predetermined time span.

In addition, evaluation device 70 may also check if the number of time pulses occurring after the end of the test-communications connection is in the interval between x and y.

As seen, the number of the currently running timer of time-measuring device 24 must be registered by testing device 10 at the start of timer 55, in order to be able to carry out the described evaluation of the measuring results.

It should be said that the location of the measuring points is preferably selected so as to render the corresponding systematic measuring error as small as possible. Thus, for the above-mentioned example, the measuring point in which the event "start of connection" is detected is located in called terminal device 30. The measuring point, in which the event "end of connection" is detected, is also in the terminal device 30 at which the connection was ended.

## List of Reference Numerals

- 10 testing device
- 20 calling, analog terminal device
- 22 detector
- 24 time-measuring device for measuring time intervals of consecutive time pulses
- 24<sub>1</sub>-
- 24<sub>N+1</sub> timer
- 26 memory in which the measured time intervals are stored together with their numbers
- 29 generator
- 30 called terminal device
- 32 generator
- 34 detector
- 40 switching network node
- 42 interface
- 44 interface
- 50 timer for measuring the time span between the start of a test-communications connection and the first time pulse
- 55 time-measuring device
- 60 memory in which the predetermined reference values are stored
- 70 evaluation device

- 80 memory in which correction values corresponding to the  
systematic measuring errors are stored
- 90 correction device
- 100 call simulator